Benchmarking of materials composition and transportation influences on Life Cycle Assessment of Recycled Aggregate Concrete

Sandrine Braymand[1], Adélaïde Feraille[2], Nicolas Serres[3], Françoise Feugeas[3]
[1] ICube, Strasbourg University, CNRS; 72 Route du Rhin, BP 10315, 67411 Illkirch Cedex, France
[2] Navier Laboratory, ENPC Paris Est University, 6 et 8 av. B. Pascal - 77455 Marne la Vallée cedex 2, France
[3]ICube, INSA Strasbourg, CNRS; 24 Boulevard de la Victoire, 67084 Strasbourg Cedex, France

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Presenting author email: nicolas.serres@insa-strasbourg.fr

Construction and demolition wastes constitute one of the largest waste streams within the developed countries [1], [2]. Resources economy and waste management incite to their recovery as recycled aggregates to be re-introduced into new concrete. This paper aims to compare the environmental impacts related to the composition of concrete to ones due to the transportation of the recycled aggregates, issued from demolition wastes, by implementing a life cycle assessment (LCA) [3]. This study is linked to the RECYBETON French Research Project involving public research laboratories, institutes and private companies. The final RECYBETON aim is to edit recommendations promoting the complete recycling of concrete as part of circular economy [4].

Materials and methods

The LCA results are presented using the EN 15804 standard impact assessment method. Life cycle assessment (LCA) of recycled aggregates concrete in comparison with a natural aggregates concrete are first realized. This part focuses on the influence of the composition parameters of the concrete, in particular the content of recycled or natural aggregates, the cement dosage and the water content. Then, close formulations of recycled aggregates concrete have been produced on an experimental construction site. LCA are performed taking into account real transport distance.

Finally, optimized formulations of concrete using superplasticizers are performed in order to obtain the same cement content for close mechanical strengths [5]. Thus, in order to take into account only the impact distance and substitution rate in this comparative study, compositions with constant formulation between natural aggregate concrete and recycled aggregate concrete (Water/Cement ratio, cement dosage, minimum strength) are studied. Four substitution rates are tested: 0, 10%, 30% and 100% (Table 1). Several transport distances of natural and recycled aggregates are proposed. These distances are calculated for several towns according to circuit illustrated Figure 1 in order to study the integrated management of demolition waste streams in several areas. Several transport distances of natural aggregates and recycled aggregates are proposed.

Table 1. Concrete compositions.

	0% RCA	**10% RCA**	**30% RCA**	**100% RCA**
Efficient Water(kg)	169	169	169	169
Eff Water + absorption Water	182	192	213	284
Cement (kg)	260	260	260	260
Natural Aggregate (NA)l (kg)	1906	1715	1334	-
Recycled Concrete Aggregate (RCA) (kg)	-	153	458	1527
Superplasticizer (kg)	1,92	1,95	2,08	2,34

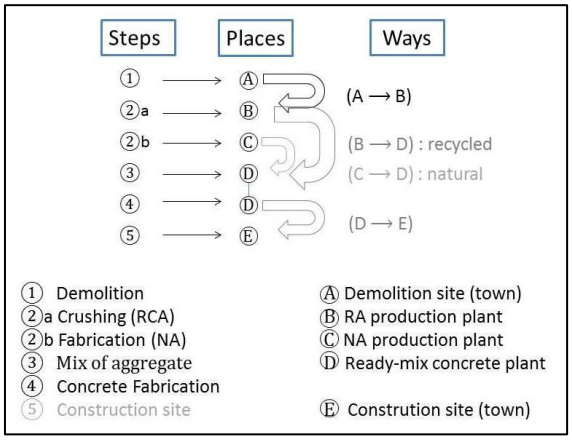

Figure 1. Transport Circuit.

Results and discussion

The use of recycled aggregates in concrete formulations increases environmental impacts at different levels in the case of variable cement content concrete. This result is due to the increase of the cement content in the samples

tested on the first part, because a standardized mechanical strength was required. For this part, short circuits for the transport of aggregates were taken as working hypothesis.

Results obtained for the experimental construction site LCA emphasizes a more important influence of impacts caused by transportation of aggregate (for hazardous and non-hazardous wastes), cement (for acidification potential, climate change, eutrophication potential and non-renewable energy) and electricity (for most part of impacts). But the trends for the two cases (RAC and NAC) are quite similar.

Before quantifying influences of substitution rate in function of transport distances, it was necessary to calculate the LCA of referent concrete established without transportation of aggregate, in that case, no significate difference was observed between RAC and NAC. The results of benchmarking of materials composition influence and transportation influence on LCA of RAC carried out are presented on Figure 2 (LCA of transport vs LCA of total process) in the case of two different towns. Depending of towns, influences of transport combined to RA substitution rates are different.

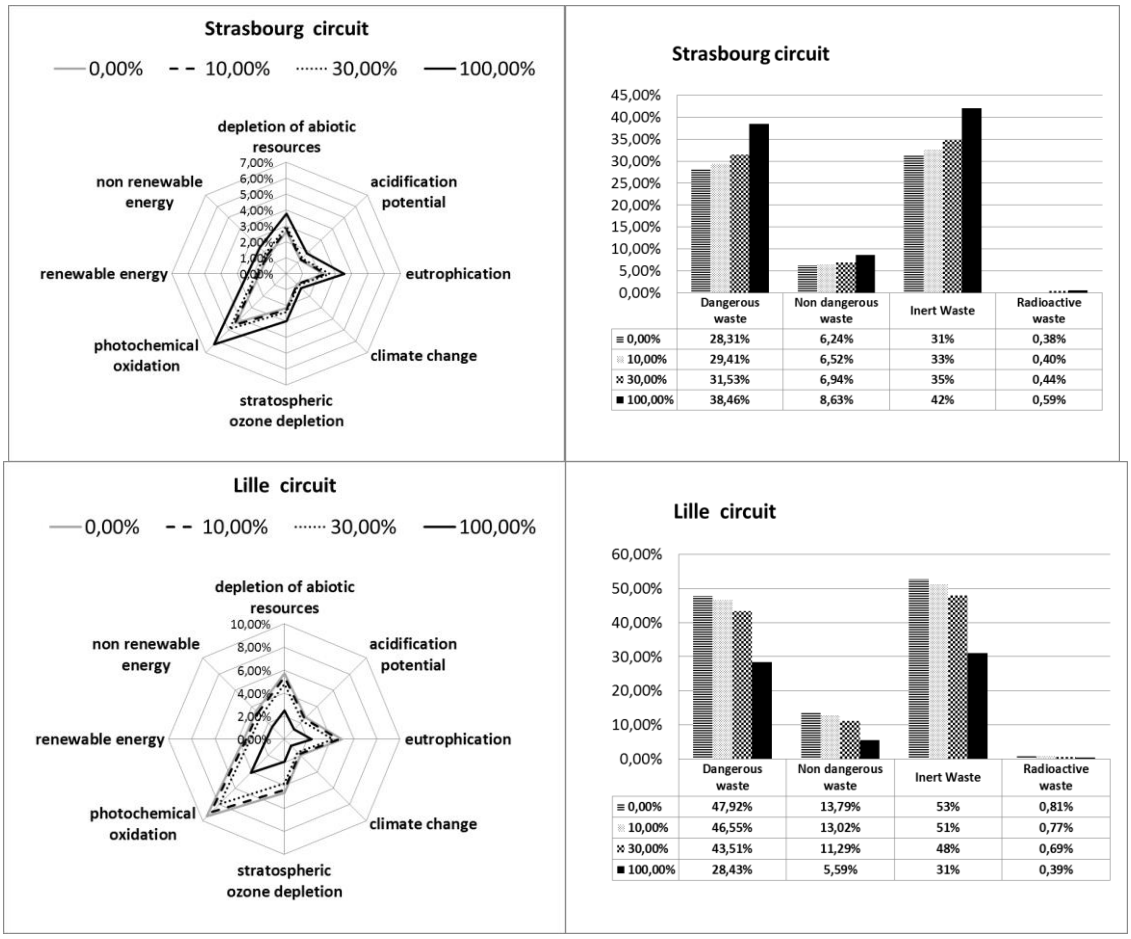

Figure 2. Transport contribution vs Total LCA in the cases of two different towns

Conclusion

Influence of material composition of recycled aggregate concrete on LCA is conditioned by the cement content. If same cement content is used, using recycled aggregate in substitution of natural aggregate doesn't changes significantly LCA. When demolition recycling plant are located in town suburb, influence of aggregates transportation on LCA of RCA is limited, not upper than 10% expected for wastes impacts but depends of territory.

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